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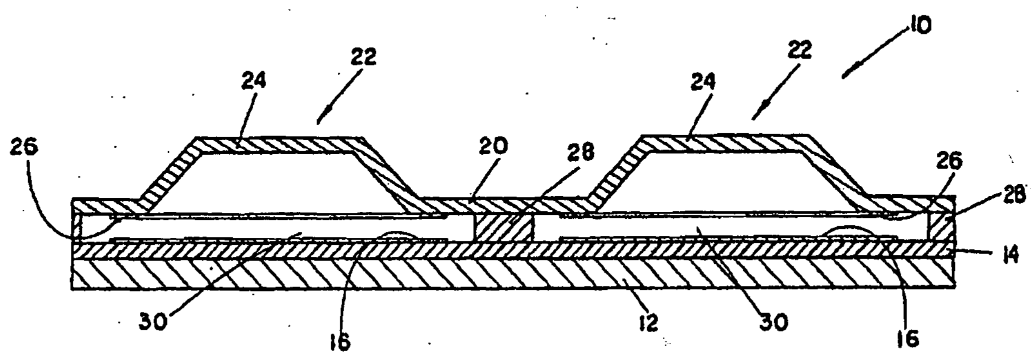
(54) Membrane switch

(57) A membrane switch assembly includes a stationary membrane switch circuit layer (16), an insulating spacer (28) or separator on the stationary membrane layer having at least one opening therethrough (30) and a movable membrane layer switch circuit on the other side of the spacer having at least one snap-action tactile element (22) extending upwardly therefrom. The stationary membrane layer has electrical conductors (16) thereon arranged in a geometrical pattern and cooperating with the openings (30) in the separator layer (28) to define an array of unique switch and circuit locations. The movable layer has a conductive contact surface 26 located on the flat surface thereof along the periphery of a tactile element (22), preferably as an annular ring, or as segments.

FIG. 3



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

FIG.1

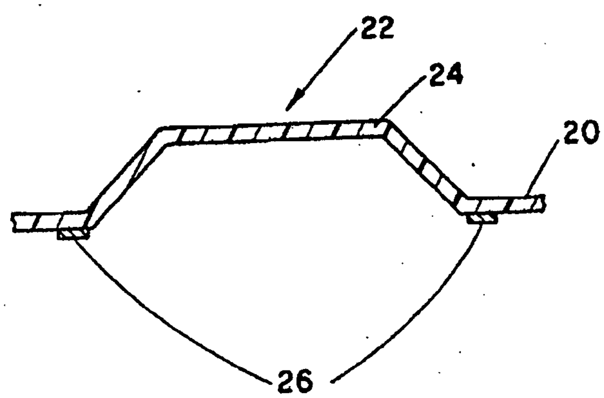

FIG.2

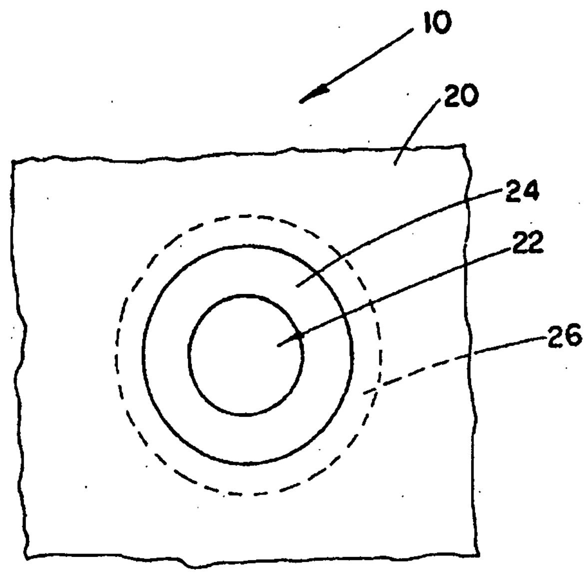

FIG.2A

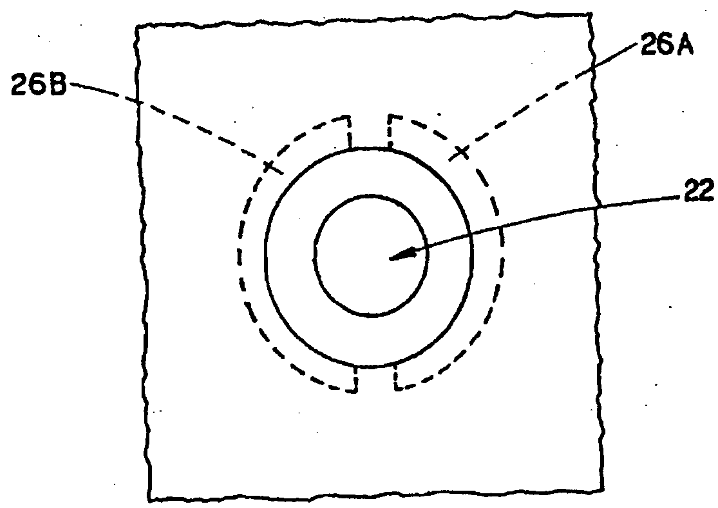

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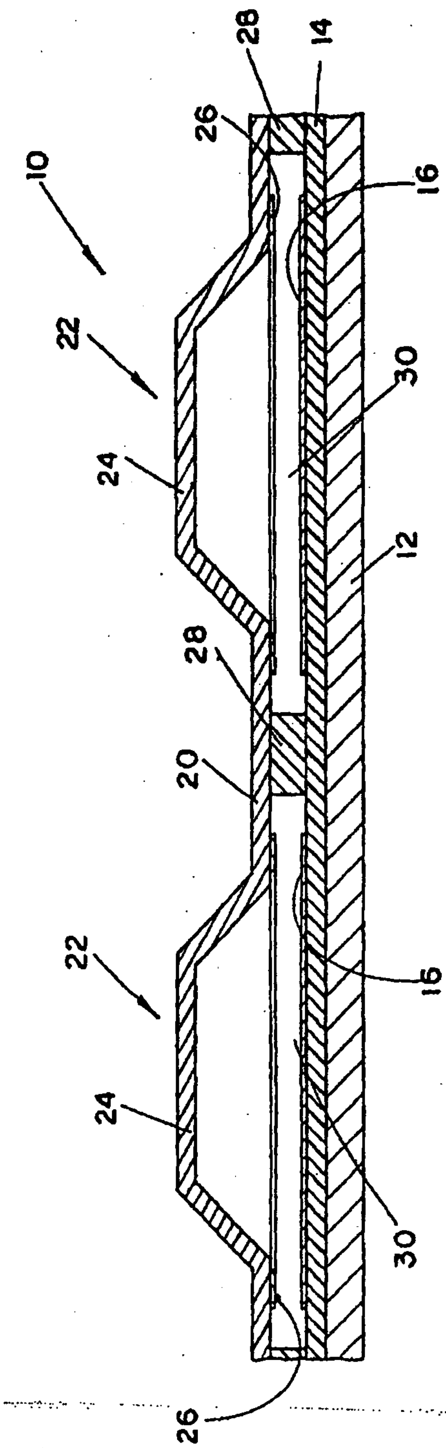
FIG. 3



SPECIFICATION

Membrane switch

This invention relates to tactile membrane keyboards. More particularly, this invention relates to tactile membrane keyboards having a strong tactile snap effect and an extremely long functional life.

Tactile membrane keyboards have found increasing use and acceptance in many commercial and domestic applications. Thus by way of example only, the keyboard has found utility in retail outlets, airline terminals, fast-food restaurant terminals, data terminals, calculators, and any other apparatus wherein digital input is necessary.

A conventional keyboard includes an array of keys which may be individually actuated to close a pair of contacts of an electrical circuit associated with each of the keys. It is often considered desirable to provide for tactile feedback so that, when the keys are pressed by the finger of a person operating the keyboard, the keys "snap" and force discontinuity is transmitted to the finger of the user indicating that the key has been actuated and an electrical signal thus generated in the circuit associated with the key.

A typical membrane type keyboard having tactility as described above is comprised of a membrane switch assembly which includes a bottom stiffener layer, a stationary membrane switch circuit layer on the stiffener, an insulating spacer or separator on the stationary membrane layer, and an active membrane switch circuit layer on the other side of the spacer. This active membrane layer is often comprised of a plurality of tactile snap-action elements such as domes which extend upwardly therefrom away from the lower stationary membrane layer. Both the stationary and active membrane layers have electrical conductors thereon (formed by printed circuit techniques such as conductive ink) arranged in a desired pattern and cooperating with holes or openings in the separator layer to define an array of unique switch and circuit locations. The application of an appropriate force to a switch site (i.e., tactile dome) on the upper surface of the active layer causes the active layer and its particular switch component to make mechanical and electrical contact through the appropriate hole in the spacer with the circuit pattern on the fixed or passive layer of the membrane.

Conventional prior art tactile membrane keyboards have a problem of a lack of reliability and uniformity in the operational or functional lifespan (i.e., number of actuations before failure) of tactile domes. To a great extent, this problem appears to result from a degradation or breakdown of the conductive ink on the active membrane layer. It is hypothesized that stress and fatigue from the continued flexing or actuating of the tactile dome eventually causes the degradation of the conductive material (e.g., ink) located on the inside surface of the dome. Thus, after such a breakdown, the tactile dome, which serves as the contact medium for conventional keyboards, will no longer effect adequate electrical contact. Breakdown of the conductive materials on the contact surface of the active layer either require the keyboard to be discarded or will create undesirably increased maintenance, replacement and labor costs for repair. Accordingly, a tactile membrane keyboard which not only retains adequate tactile (snap-action) feedback, but also has an improved or extended operating life would be highly desirable and advantageous.

In accordance with the present invention, there is provided a membrane switch comprising a first circuit sheet, said first circuit sheet having at least a first sheet of insulating material with first electrically conductive contact means thereon, a said second sheet having a second sheet of insulating material, at least one tactile element formed in and extending from said second sheet, said second sheet of insulating material defining a flat surface at the base of said tactile element, second-electrically conductive contact means on said flat surface about the periphery of said tactile element, spacer means between said first and second circuit sheet, said spacer means having a plurality of openings therein whereby said tactile element is actuable under an applied force to move said second conductive contact means through said opening and into electrical contact with said first conductive contact means.

As in the prior art keyboards, the lower stationary membrane layer has a contact area of electrical conductors (e.g., copper traces or conductive ink) thereon arranged in a pattern and cooperating with holes in the separator layer to define an array of unique switch and circuit locations. Unlike the prior art, a novel improvement of the present invention lies in the positioning and structure of the contact surface of the active layer. This novel contact surface, which may be comprised of conductive ink or other conductive material, is applied to the active layer, around the periphery of the base of a dome on the flat surface of the active layer, preferably as an annular ring. Thus, as no part of the upper contact ring surface is adhered to the flexing surface of the dome as in the prior art, the conductive material comprising the contact surface will not be subject to the previously discussed stress or fatigue and resultant breakdown when the dome is repeatedly actuated over a long period of time. The tactile membrane keyboard of the present invention, therefore, exhibits a markedly improved and extended operating life which in turn, provides improved efficiency and greater reliability and

economy to the keyboard purchaser and manufacturer. Note that the present invention requires the use of less conductive ink than in the prior art and therefore reduced manufacturing costs.

In order to accomplish this modified annular contact structure along the periphery of the domes, the diameter of the openings in the spacer or separator is increased relative to conventional keyboards. Similarly, the contact area of the lower stationary layer is correspondingly increased to equal that of the openings. Thus, sufficient room is provided for the annular contact rings on the active layer so that, upon actuation of the dome, the annular ring will have an open path to effect contact with the electrical conductors on the stationary layer. The particular structural arrangement of the present invention provides electrical contact prior to the dome having travelled its full course, with the full travel of the dome and snap action or tactile feedback telling the operator that switch actuation has occurred.

Various modifications and embodiments of the tactile membrane keyboard of the present invention include segmenting one or both switch contact surfaces in order to permit multiple parallel contacts on both the upper and lower circuit layers. Also the present invention is equally applicable to a multiplicity of dome configurations including, but not limited to, oval domes and ramp-shaped domes. Finally, the absence of conductive material along the inside surface of the snap-action dome permits the incorporation of back-lighting, i.e, illumination from beneath the keys.

The above-discussed and other advantages of the present invention will be apparent to and understood by those skilled in the art from the following detailed description and drawings.

Referring now to the drawings, wherein like elements are numbered alike in the several figures:

Figure 1 is a partial cross-sectional elevation view of the upper portion of an individual tactile membrane element in accordance with the present invention.

Figure 2 is a plan view of the tactile dome of Fig. 1 in accordance with the present invention.

Figure 2A is a view similar to Fig. 2 of a modified construction.

Figure 3 is a cross-sectional elevation view showing a tactile membrane keyboard assembly in accordance with the present invention.

Referring to the Figures, a portion of a keyboard in accordance with the present invention is shown. In the Figures, one or two key locations are shown, but it will be understood that an entire keyboard is made up of a monolithic membrane circuit structure comprised of any number of individual tactile domes or keys, the specific number being determined by the requirements of the particular keyboard and application.

A two key portion of a monolithic membrane keyboard or circuit array 10 is shown in Fig. 3. The monolithic membrane keyboard or switch structure includes a bottom stiffener sheet or rigidizing layer 12 which may be a plastic or metal sheet with stiffness and flatness equivalent to aluminum 6061 alloy of approximately 0.5 mm thick. Stiffener 12 serves to support and maintain in planar condition a fixed or passive layer circuit sheet of the key switch assembly which consists of a lower insulating layer or sheet 14, preferably of Mylar polyester film, and a lower circuit pattern 16 formed thereon. This fixed or passive key switch layer or circuit sheet is adhesively bonded to stiffener 12. Insulating layer 14 may be of any desired thickness, preferably between 0.05 mm to 0.18 mm and the conductive pattern thereon may be formed by any known printed circuit technique, such as by printing with a conductive ink, printing or etching a conductive metal foil, etc. Preferably, the conductive pattern 16 should be reasonably thin (on the order of 0.01 to 0.05 mm in thickness, and preferably about 0.025 mm thick).

A movable or active switch layer or upper circuit sheet is positioned above the lower circuit pattern 16. The movable or active switch layer comprises an upper insulating layer 20, e.g. Mylar. The upper insulating layer 20 has an array of snap-action protrusions or tactile elements 22 in the shape of an arcuate dome 24 of truncated cone shape having a flattened top surface. As mentioned, the present invention is equally applicable to tactile domes of other shapes incudling, but not limited to, semispherical domes, oval-shaped domes, ramp domes, etc. The insulating layer 20 of the active switch layer has a printed circuit conductor or contact surface 26 having the shape of an annular ring and formed by any known printed circuit technique (e.g., conductive ink). This annular ring-shaped contact surface 26 runs around the outer periphery of the dome 24 base and is adhesively or otherwise bonded to the flat surface of the active switch layer.

An insulating spacer or separator layer 28 having a plurality of openings 30 may be adhesively or otherwise fixed in position on one side to the stationary layer on which the lower circuit pattern 16 is located, and on the other side to the upper insulating layer 20. The total thickness of the spacer 28 may be used to adjust the distance between the upper conductor 26 and the lower circuit pattern 16. The opening 30 in spacer 28 must be larger than the diameter or outer dimensions of conductor pattern 26 so as to allow the dome 24 to snap through and deflect pattern 26 into contact with the circuit pattern 16 in order to achieve electrical contact between the

switch components.

The array of flat-top arcuate domes 24 and correspondingly bonded annular ring-shaped circuit conductors 26 are positioned above the lower circuit pattern 16 such that the domes 24 protrude upwardly away from the lower circuit pattern. This arrangement defines an array of unique circuit locations or switch sites. When a force of sufficient magnitude is imposed on a dome 24, the protrusion 22 is moved downwardly in a snap-action through the opening 30 in spacer 28 moving the annular contact surface 26 into electrical and mechanical contact with the lower circuit pattern 16. This electrical contact acts to close a switch and deliver an electrical signal. It should be understood that the novel design of the present invention results in electrical contact taking place between the respective contact surfaces 16 and 26 prior to the dome having travelled its full course. Nevertheless, the necessary tactile feedback is achieved as the dome will continue in its travel path, resulting in snap action whereby the keyboard operator perceives that contact has been accomplished.

As discussed earlier, a major problem in conventional prior art membrane keyboards has been a lack in reliability and predictability of the functional lifespan of the keyboards. This problem is overcome by the membrane keyboard of the present invention. While in the prior art, the upper conductive contact surface was adhesively applied to the inside of a dome, in the present invention, the upper conductive surface 26 is formed preferably as an annular ring on the flattened surfaces of insulating layer 20 (as opposed to the flexing area within the dome). The advantage of the annular conductive surface 26 is far decreased stressing fatigue and less flexing of the surface 26. In other words, since no part of the contact ring surface 26 is adhered to any surface of the dome 24, the surface 26 will not be subject to the repeated stressing and flexing of the inner surface of the dome 24 during key actuation. The lower fatigue associated with the present invention therefore results in longer life of the active contact element.

Another difference between the present invention and the prior art is the comparative dimensioning of the openings 30 in spacer 28 and the lower contact surface 16 on the passive layer 14. In order to construct a membrane keyboard in accordance with the present invention, the relative dimensioning of the component parts has to be such that the upper annular contact surface 26 can freely make electrical and mechanical contact with the lower contact surface 16, while the plurality of domes 24 retain the required tactile, snap-action feature. Accordingly, the diameter of the openings 30 in the spacer 28 is increased relative to the prior art spacer openings. Similarly, the diameter of the lower contact surface 16 on lower insulating layer 14 is correspondingly increased. Thus, the annular flat area on the inside surface of insulating layer 20 capable of supporting annular contact surface 26 is exposed to the lower contact surface 16 so that contact may be effected therebetween.

In an alternative embodiment of the present invention, the contact surfaces 16 and 26 may be segmented so as to permit multiple, parallel contacts on both the upper and lower membrane layers. The segmented upper contact surface is shown in Fig. 2A, where the tactile element or dome 22 is surrounded by arcuate contact segments 26a and 26b. The contact surface 16 would be similarly segmented. This segmented configuration is very difficult, if not impossible to accomplish with conventional tactile membrane keyboards wherein the upper contact surface is secured to the inside surface of the dome.

The tactile membrane keyboard of the present invention is extremely economical for both the purchaser and manufacturer. The improved operational lifespan and greater reliability translates into far lower replacement and maintenance costs. Similarly, from the manufacturer's standpoint, the annular ring of conductive ink, paint or other conductive surface requires less material than in the prior art. Also, if the conductive contact surface 16 on the lower passive layer is shaped like an annular ring of the same configuration as the annular ring 26 on the active layer (rather than a full contact pad), then even less conductive ink or the like will be needed at a great cost savings.

A further advantage of the present invention is the possibility of illuminating the key legend from beneath the keys. In the prior art, the presence of conductive ink or the like underneath the dome prevented a light source from penetrating therethrough. Since, in the present invention, conductive ink is only around the periphery of each key, it is not in a position to block light transmission through the key and therefore backlighting illumination may easily be provided if so desired.

CLAIMS

1. Membrane switch comprising:
a first circuit sheet,
said first circuit sheet having at least a first sheet of insulating material with first electrically conductive contact means thereon,
a second sheet having a second sheet of insulating material,
at least one tactile element formed in and extending from said second sheet
said second sheet of insulating material defining a flat surface at the base of said tactile element,
second electrically conductive contact means on said flat surface about the periphery

of said tactile element,

spacer means between said first and second circuit sheet,

said spacer means having a plurality of openings therein whereby said tactile element is actuable under an applied force to move said second conductive contact means through said opening and into electrical contact with said first conductive contact means.

2. A membrane switch as claimed in Claim 1, wherein said tactile element is a snap-action dome.

3. A membrane switch as claimed in Claim 2, wherein said snap-action dome has an arcuate shape with a flat top.

4. A membrane switch as claimed in any one of Claims 1 to 3, wherein said second conductive contactor means has an annular shape.

5. A membrane switch as claimed in Claim 4, wherein said first conductive contactor means has an annular shape corresponding to said second conductive contactor means.

6. A membrane switch as claimed in any one of Claims 1 to 5, wherein said first and second conductive contactor means are comprised of a conductive ink.

7. A membrane switch as claimed in any one of Claims 1 to 6, wherein said first and second conductive contactor means are segmented thereby permitting multiple parallel contacts on said upper and lower circuit sheet means.

8. A membrane switch as claimed in any one of Claims 1 to 7, including a stiffening sheet in supporting attachment to said lower circuit sheet means.

9. A membrane switch as claimed in any one of Claims 1 to 8, wherein said tactile element is free of electrically conductive material within the periphery of said tactile element, whereby said tactile element is suitable for backlighting.

10. A membrane switch substantially as hereinbefore described and as illustrated in the accompanying drawings.

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(72) Inventor KEITH ANTHONY THOMAS KNOX

(19)

(54) ELECTRICAL SIGNAL INITIATING KEYBOARDS

(71) We, THE POST OFFICE, a British body corporate established by Statute, of 23 Howland Street, London, W1P 6HQ, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrical signal initiating keyboards and more particularly, but not exclusively, to telephone instrument push-button keyboards.

Telephone instruments currently in use employ the familiar dial unit as a means for generating a train of electrical impulses representing the number of the subscriber being called. The dial unit has proved generally satisfactory and relatively cheap for this purpose, but being purely mechanical in operation can suffer from wear after long use. The operation of the dial can be somewhat tiring to the caller when many calls are to be made, particularly as trunk calls generally require ten dial movements per call.

Electrical signal initiating keyboards in the form of push-button keyboards are used in telephone instruments as an alternative to the dial unit for initiating a destination coded signal. The signal produced by a push-button keyboard is not necessarily transmitted as a train of electrical impulses as for the dial unit. Prior art push-button keyboards have proved preferable to the dial unit so far as ease of use by the caller is concerned but have nevertheless proved unsatisfactory in other respects. For example, push-button keyboards using moving electrical contacts have been found to incur a fault liability, particularly when operated in low impedance circuits. Push-button keyboards utilising a discrete electronic device for each button (for example, piezo-electric crystals or Hall effect devices) have been proposed but are generally more expensive than the familiar dial unit.

It is an object of the invention to provide an improved electrical signal initiating keyboard.

The present invention provides an electrical signal initiating keyboard including:

a number of motion transmitting elements;

a layer of resiliently deformable insulating foam material having at one face thereof a plurality of electrically conductive tracks defined by conductive particles and separated by non-conductive areas of the foam; and

a plurality of terminals connected to associated ones of the tracks the arrangement being such that each motion transmitting element is operable to deform a respective area of the foam material to thereby change the resistance between terminals associated with that particular area.

Preferably, the insulating foam material is a polyether polyurethane foam with conductive tracks formed by graphite particles therein.

The motion transmitting elements can be push-buttons manually operable to compress the foam material against a rigid plate.

By way of example only, two illustrative embodiments of the invention will now be described with reference to the accompanying drawings, of which:—

Figure 1 shows a plan view of a variable resistance element employed in the embodiments;

Figure 2 shows an "exploded" view, partly in section, of a first electrical signal initiating keyboard embodying the invention;

Figure 3 shows a cross-sectional view through part of the keyboard of Figure 2;

Figure 4 shows an "exploded" view, partly in section, of a second electrical signal initiating keyboard embodying the invention;

Figure 5 shows a cross-sectional view through part of the keyboard of Figure 4;

Figure 6 illustrates the electrical operation of the keyboards;

Figure 7 shows an approximate equivalent circuit for the keyboards;

Figure 8 shows one way of combining the outputs of the keyboards; and

Figures 9A and 9B show how resistance characteristics can be modified by the use of additives.

It should be noted that in the interests of clarity the drawings have been simplified and relative dimensions exaggerated in places.

Referring to Figure 1, a resiliently deformable variable resistance element employed in both the embodiments comprises a piece of insulating foam 1 with conductive tracks 2 applied to one surface thereof. The foam 1 is a polyether polyurethane foam approximately 3 inches by 4 inches and 0.4 inches thick. The foam has a fine cell structure, an example of a suitable foam being "Kayfoam Polyether E35" (density 22 kg/M^3) manufactured by Kay-Metzeler Ltd., of Cheshire. The conductive tracks 2 are applied in the pattern shown by screen printing or by use of a contoured roller and comprise graphite particles. A suitable material for forming the conductive tracks 2 is that known by the registered Trade Mark "AQUADAG" and of the grade having an 18% solids content. To ensure that the graphite particles bond firmly to the foam and to improve the rheological properties of the AQUADAG during application certain additives are preferably mixed with the AQUADAG before its application. For example, up to 5% of 50—60% strength vinyl acetate-vinyl versatate copolymer (such as that sold by Vinyl Products under the trade name "Vinapol 1070") can be added to improve bonding. Sodium alginate is a suitable material for thickening the AQUADAG to modify its rheological properties so that excessive lateral diffusion does not occur during the printing process. The use of sodium alginate can also decrease the contact resistance of the conductive tracks 2 and the use of 1 part of a 2% aqueous sodium alginate solution (preserved with formaldehyde) to 3 parts AQUADAG was found successful in this respect (this concentration represented approximately 0.5% sodium alginate dry weight). It was also found that the property of sodium alginate to decrease contact resistance could itself be modified by use of a gelling agent. For example, the introduction of Ca^{++} ions by the use of $CaCl_2$ and compensated by the addition of $EDTANa_2$ (a sequestering agent) produced a high contact resistance at low pressure and thereby increased the range of resistance variation since the contact resistance at large pressure was substantially unchanged. Alternative materials for modifying the contact resistance properties of the conductive tracks 2 are dimethyl sulphoxide (DMSO) at about 5—15%, cetrimide at about 1%, benzalkonium chloride, cetyl trimethyl ammonium bromide and a liquid anionic detergent based on mixed sodium alkyl sulphates of long chain alcohols such as TEEPOL (RTM).

Figure 9A comprises a graph showing the effect of various additives on surface resistance and Figure 9B is a similar graph relating to bulk resistance. Each graph shows eleven curves, a to g inclusive, and the various additives represented by these curves are set out below:

Curve a — Vinapol vinyl acetate-versatate copolymer in the concentration given above
Curve b — as for curve a but with the additive of sodium alginate in the concentration given above
Curve c — as for curve b but with the addition of a trace of benzalkonium chloride
Curve d — as for curve b but with the addition of cetyl trimethyl ammonium bromide
Curve e — as for curve b but with the addition of TEEPOL
Curve f — as for curve a but with the addition of a trace of benzalkonium chloride
Curve g — as for curve a but with the addition of 15% DMSO
Curve h — as for curve a but with the addition of 5% DMSO
Curve i — as for curve a but with the addition of 5% DMSO and of cetyl trimethyl ammonium bromide
Curve j — 5% DMSO
Curve g — 15% DMSO

There is no resistance value shown for zero applied force (light contact) for curves, b, c, d, e, f, and g of Figure 9A as a spacer was used to ensure very high resistance at zero applied force.

The following points are notable:

(i) Curve a shows only a small change in bulk resistance in comparison with the change in surface resistance with applied force.

(ii) Curve b illustrates that resistance is increased by the use of sodium alginate.

(iii) Curves c and f show that the effect of benzalkonium chloride is to bring about an increase in the change of resistance with applied force, particularly so for bulk resistance.

(iv) Curve e shows that TEEPOL exerts a similar effect to benzalkonium chloride.

(v) Curve h shows an increased resistance at zero applied force but without commensurate increase in resistance when force is applied, there is an increased range of bulk resistance change.

Referring now to Figures 2 and 3, a keyboard for use in a telephone instrument comprises twelve depressible keys or buttons 3 arranged in a matrix of 4 rows of 3 keys. Each key is suitably inscribed with an alphanumeric symbol or legend (not shown). Ten of the keys are used to signal the digits 0 to 9 for a telephone number code and the remaining two keys are used for auxiliary purposes, for example, "special facilities" and "service facilities".

The keys 3 are located on an upper plate 4 which is a onepiece moulding of a rigid plastics materials of a generally flat form. Each key 3 respectively comprises a peg 5

projecting through a hole in the plate 4 with a flange portion 6 at its lower end. The other end of the peg 5 is received in a cap 8, the cap either being a tight push fit on the peg or being retained by adhesive. Each peg 5 is a sliding fit in its respective hole and, if desired, a helical compression spring 9 acting against the top of the plate 4 and the underside of the cap 8 and positioned about the peg can be included in the key assembly. Such springs are not strictly necessary since their function (to bias the keys in an up position) can be accomplished by the resiliency of the foam 1 without further aid.

A set of cross-members, such as reference 10, and a peripheral member 11 are provided to ensure the rigidity of the plate 4.

Positioned beneath the plate 4 is the insulating foam 1 with its conductive tracks 2 positioned downwardly. Connections (not shown in Figure 2) are made to the conductive tracks by stapling, eyeletting or by use of a conductive cement.

An insulating spacer 12 is positioned beneath the foam 1 and comprises a piece of polythene film in the range 0.006 to 0.020 inches thick with twelve holes 13 each underlying a respective key 3. Foam material can be used as an alternative to film and other types of polymer can be used. As another alternative, paper can be used. It is, however, preferred that the thickness of the spacer 12 should be greater than 0.002 inches and less than 0.150 inches.

A layer of conducting material 14 to which a connection is made (not shown in Figure 2) is positioned beneath the spacer 12. The conducting material 14 can be carbon-loaded paper, metallised polymer foil or, less desirably, tin-oxide coated glass. If the conducting material comprises a conducting layer on an insulating layer, rather than being a homogeneous conductor, it is placed conductive side up. A pick-off connection of the conducting material 14 is made by stapling, eyeletting or the use of a conductive cement.

A base-plate 15 of rigid plastics material is positioned beneath the material 14. Assembly of the various parts of the keyboard can conveniently be achieved by use of an insulating adhesive.

The electrical operation of the keyboard will be discussed later.

Referring now to Figures 4 and 5, a second form of Keyboard for use in a telephone instrument is illustrated. The similarity of this second keyboard to the first keyboard is immediately apparent and therefore description will be confined to pointing out the difference between the two keyboards.

In the second keyboard, the keys 3 form an integral part of the plate 4 which is of a resilient plastics material. The cross-members 10 and peripheral member 11 impart stiffness to the plate 4 and divide it into twelve areas, each area containing a key 3. It is thus possible to depress any one of the keys against the resiliency of the plate 4 with negligible movement of the other keys.

The conductive layer 14 (conducting side down if a conductor/insulator laminate is used) is positioned beneath the plate 4 and the remaining components are positioned in the order, spacer 12 foam material 1 (conductive tracks uppermost) and plate 15. In this embodiment the layer 14 has to resist distortion due to cyclic distortion and is therefore preferably constructed from a polymeric material..

The two embodiments differ only in mechanical operation, their electrical operation is essentially the same. Referring to Figure 6, it will be seen that a respective terminal is connected to each conductive track 2 and these terminals are referenced A, B, C etc. up to O. Each conductive track makes contact when an associated key is depressed with conductive material 14 through a hole 13 and this feature is illustrated by the hatched circles in Figure 6. The conductive tracks connected to terminals A, B, C, D, F, G, H, I, L, M, N, O each overlie one hole 13 whereas the conductive tracks connected to terminals E, J, K, each overlie four holes 13. Each of the hatched circles in Figure 6 corresponds, of course, to a respective key and this feature is illustrated by marking the circles with respective symbols 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, X and Y. Depression of the key bearing the number 1, for example, cause compression of the part of the foam on which the conductive tracks connected to terminals D and E are positioned. Compression of the foam by an overlying key results in the conductive tracks underlying the key being brought into contact with the conductive layer 14. The resistance on contact decreases with increased pressure on the key and in an experimental keyboard was found to be 100 k for 40 Z, 50 k for 80 Z and 15 k for 16 OZ. The spacer ensures infinite resistance when the key is underpressed. Thus, a resistance drop is observed between terminal D and layer 14, and between terminal E and layer 14 when the key bearing the number '1' is depressed.

Figure 7 shows an approximate equivalent circuit for the keyboards. Terminal E, for example, is shown connected to layer 14 by four variable resistors in parallel, each resistor corresponding to one of the four possible connections of the track to layer 14 through holes 13.

The resistance change with increased pressure is believed to be due almost entirely to changes in surface contact resistance and it is believed that bulk resistance changes are insignificant so far as the overall effect is concerned.

Figure 8 shows one way of connecting the keyboards to provide a "2 out of 7" coded in-

dication of which key is depressed. Terminals A, G, O are commonly connected to a line reference α, similarly B, F, N; C, I, M; and D, H, L are connected to β, γ and δ respectively.

Terminals E, J and K respectively connected to lines ϵ, ζ and η. It can easily be seen that if, for example, the key bearing the number '3' is depressed the resistance between lines η (connected to K) and δ (connected to L) and conductive layer 14 drops. Thus, if different electrical signals are applied to the lines α, β, γ, δ, ϵ, ζ and η two of these signals will be communicated to the conductive layer 14. The table below sets out the operation of the keyboard connected as shown in Figure 8.

Key	Resistance change
1	$\delta\ \epsilon$
2	$\delta\ \zeta$
3	$\delta\ \eta$
4	$\gamma\ \epsilon$
5	$\gamma\ \zeta$
6	$\gamma\ \eta$
7	$\beta\ \epsilon$
8	$\beta\ \zeta$
9	$\beta\ \eta$
0	$\alpha\ \zeta$
X	$\alpha\ \epsilon$
Y	$\alpha\ \eta$

The keyboards are, of course, connected to suitable interface equipment for use in generating dialling code pulses or frequencies.

It will be appreciated that many modifications to the described embodiments are possible. For example, the spacer plate 12 can be omitted so that there is finite resistance associated with unactuated keys. The use of the additives mentioned earlier helps to obtain a high range of values between 'off' resistance (lightly contacting) and 'on' resistance (14 contacting under finger pressure).

If desired, each key can be arranged to act against a metal spring so that a snap-action and an audible "click" is obtained on depressing the key.

The conductive layer 14 can be in the form of an interconnected metallic pattern corresponding to the holes 13 on an insulating layer.

It is a notable feature of the described embodiments that expensive materials such as gold are not required and that the keyboards have a much smaller fault liability than the prior art moving contact type of keyboard.

WHAT WE CLAIM IS:—

1. An electrical signal initiating keyboard including:

a number of motion transmitting elements;

a layer of resiliently deformable insulating foam material having at one face thereof a plurality of electrically conductive tracks defined by conductive particles and separated by non-conductive areas of the foam; and

a plurality of terminals connected to associated ones of the tracks the arrangement being such that each motion transmitting element is operable to deform a respective area of the foam material to thereby change the resistance between terminals associated with that particular area.

2. A keyboard as claimed in claim 1 wherein the motion transmitting elements are push-buttons manually operable to compress the foam material against a rigid plate.

3. A keyboard as claimed in claim 2 wherein the push buttons form an integral part of a plate of resilient plastics materials.

4. A keyboard as claimed in any preceding claim including means to provide a snap-action for the motion transmitting elements.

5. A keyboard as claimed in any preceding claim wherein the foam comprises polyether polyurethane foam.

6. A keyboard as claimed in any preceding claim wherein the conductive particles comprise graphite particles.

7. A keyboard as claimed in claim 6 wherein the conductive particles comprise graphite particles in association with a resistance-modifying additive.

8. A keyboard as claimed in claim 7 wherein the additive is sodium alginate, or dimethyl sulphoxide, or cetrimide, or vinyl acetate-versatate copolymer, or benzalkonium chloride, or cetyl trimethyl ammonium bromide, or a liquid anionic detergent based on mixed sodium alkyl sulphates of long chain alcohols.

9. A keyboard as claimed in any preceding claim wherein a layer of electrical insulating material having a plurality of apertures therein is provided between the conductive tracks and a layer of electrically conducting material and wherein the motion transmitting elements are operative to press the conductive tracks and conductive layer into contact through the said apertures.

10. A keyboard as claimed in claim 9 wherein the motion transmitting elements act against the foam material.

11. A keyboard as claimed in claim 9 wherein the motion transmitting elements act

against the conductive layer, the said layer being resilient.

12. An electrical signal initiating keyboard substantially as herein described with reference to and as illustrated by Figures 1, 2, 3 and 6 or by Figures 1, 4, 5 and 6 of the accompanying drawings.

13. A telephone instrument including a keyboard as claimed in any preceding claim.

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1 412 298 COMPLETE SPECIFICATION
6 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

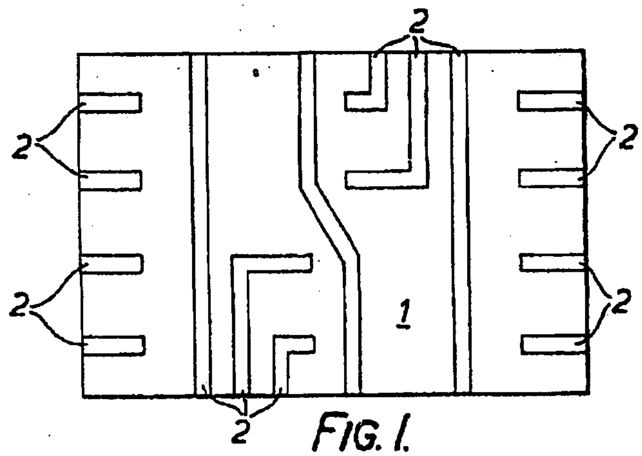


FIG. 1.

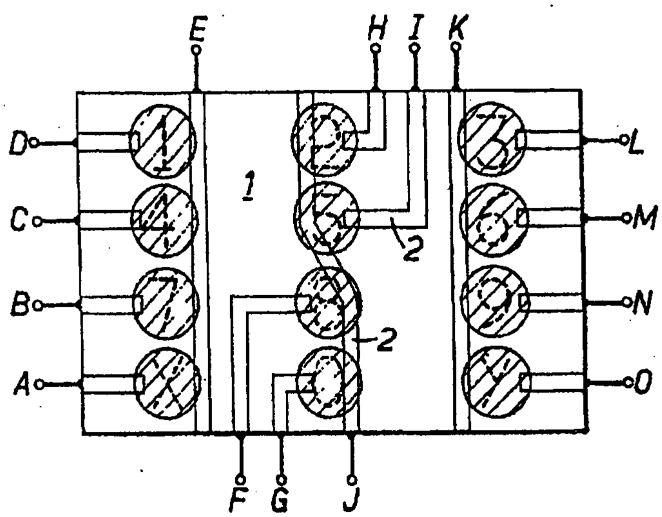


FIG. 6.

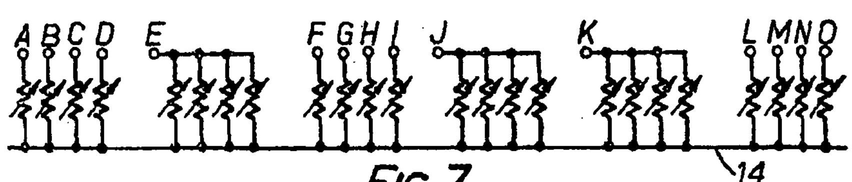


FIG. 7.

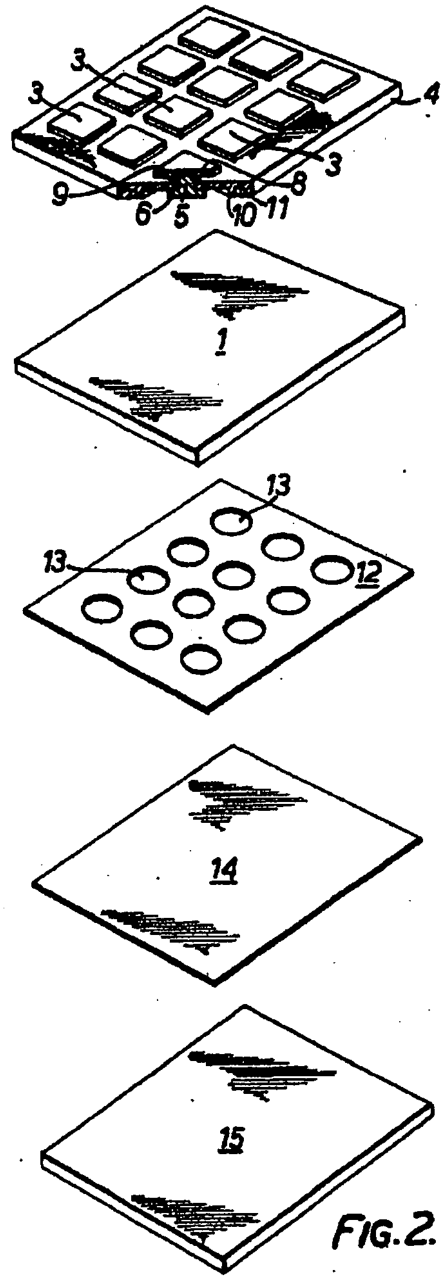


FIG. 2.

1 412 298 COMPLETE SPECIFICATION
6 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 3

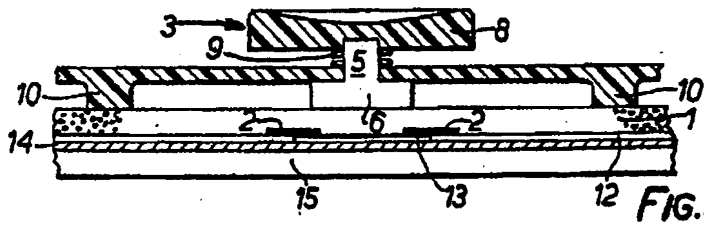


FIG. 3.

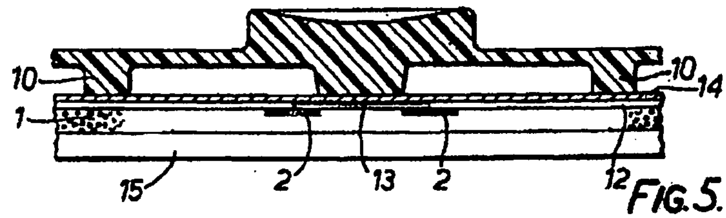


FIG. 5.

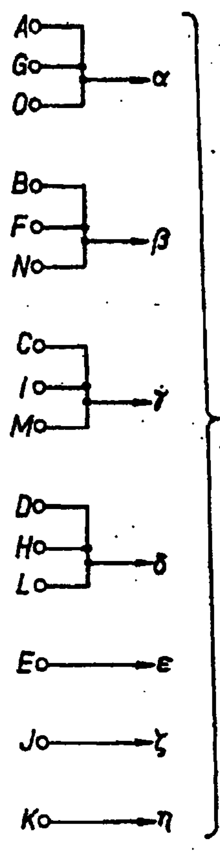


FIG. 8.

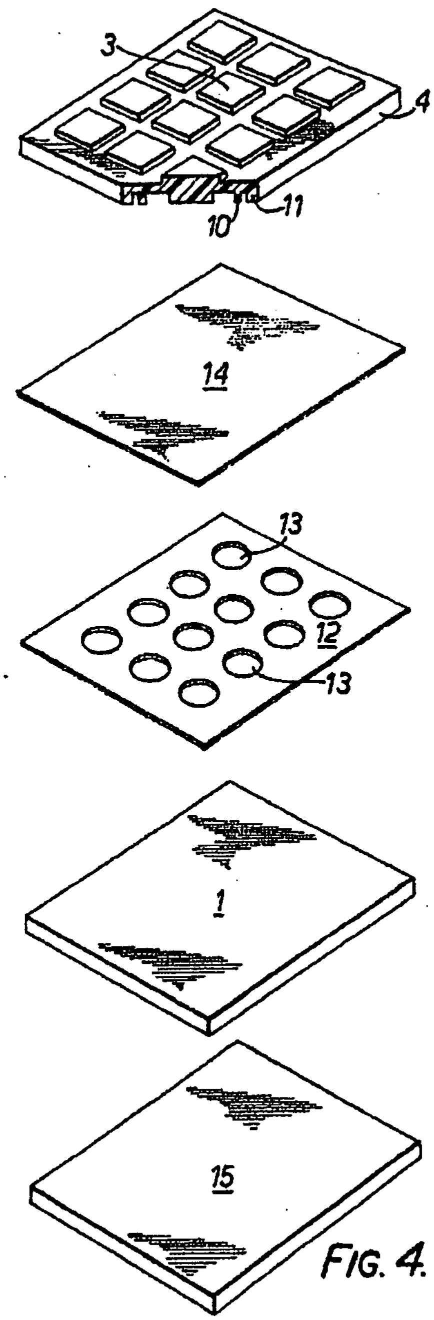
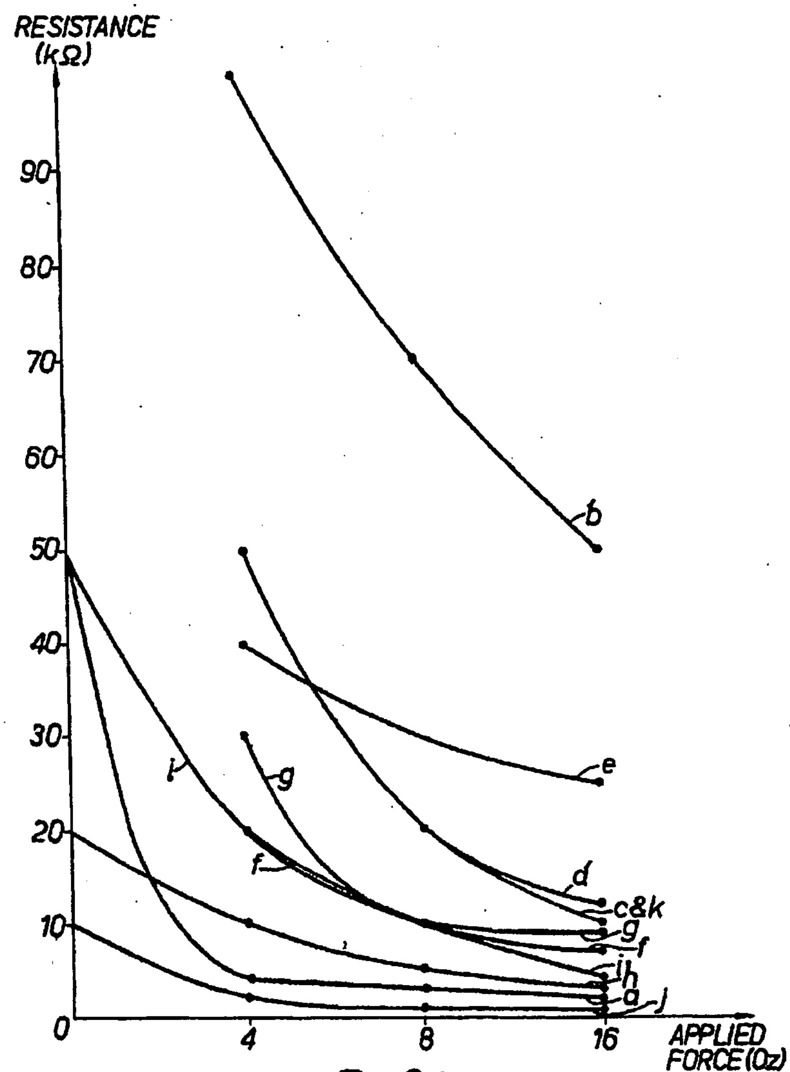


FIG. 4.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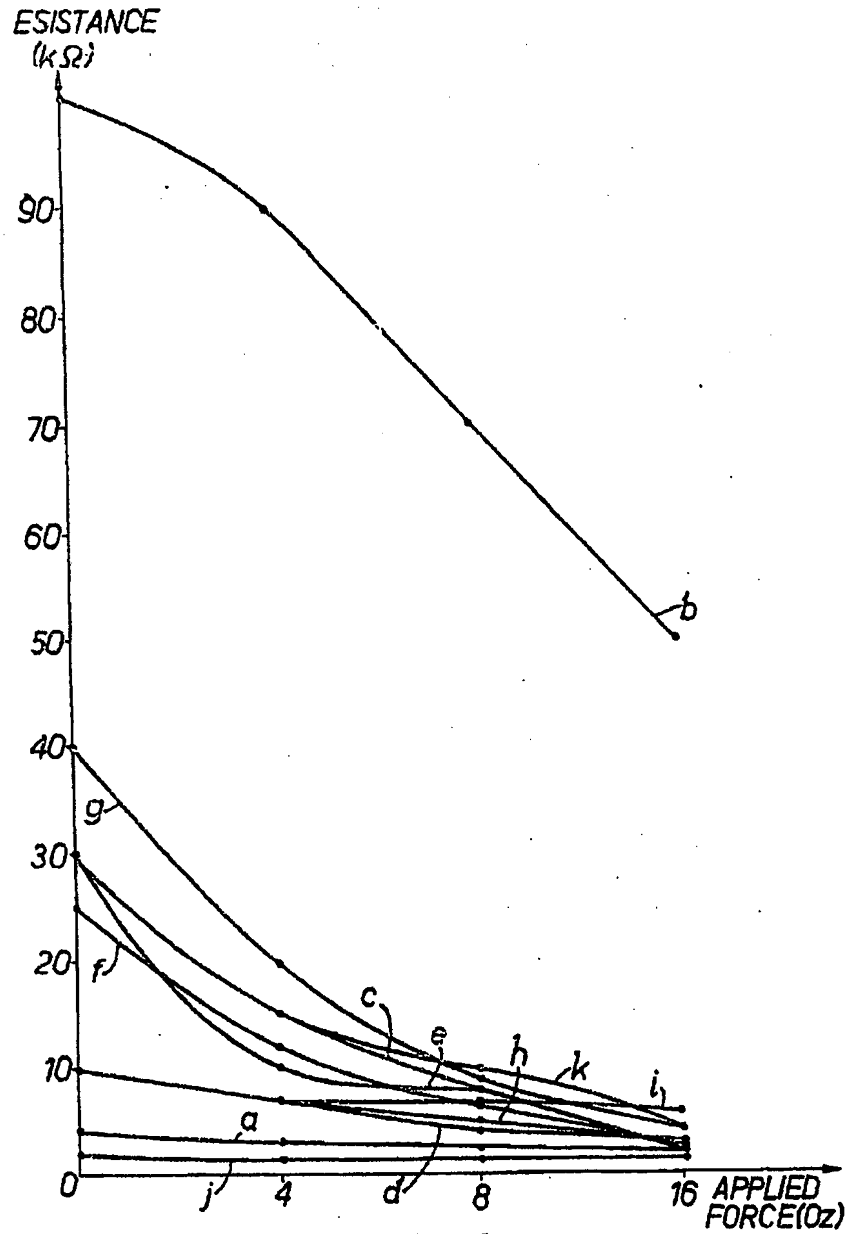
70
60
50
40
30
20
10
0
4
8
16
APPLIED FORCE (Oz)
b
e
d
c&k
g
f
i
h
a
j

FIG. 9A.


ESISTANCE
(kΩ)
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80
70
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50
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30
20
10
0
b
g
f
c
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h
k
i
a
d
j
4
8
16
APPLIED
FORCE(Oz)

FIG. 9B.